Assessing Remediated Waste Water Modifications for Use as a Microbial Fertilizer in Urban Agriculture

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Introduction

The Searle Biodiesel Lab is a part of the Institute of Environmental Sustainability (IES) at Loyola University Chicago. The biodiesel program began in 2007 as a result of a STEP course (Solutions to Environmental Problems) that explored the feasibility of establishing a biodiesel production facility on our Lakeshore campus. The intent of any STEP course at Loyola (Food Systems, Water, Climate Actions) is to encourage students to think about ways they that can positively contribute change on campus in a sustainable manner.

One of the main goals of the Biodiesel Lab, as well as the Institute of Environmental Sustainability in general, is to reduce the amount of waste that we accumulate. One of the only byproducts of biodiesel production that is not being reused in the Searle Biodiesel Lab is the wastewater that results from washing the final biodiesel product. Currently, the main solution to this problem is to acidify the wastewater and get as much biodiesel as possible off of it, and then use the leftover acidified water to grow algae that are harvested to feed to fish in an aquaponics system. Once the algae is harvested, the water still is not used for anything and is discharged to a water treatment facility. But, this water is still full of nutrients that can be beneficial. The goal of this project is to determine a way to use this leftover water, which we call "nutrient water." This is meant to fit in to the overall goal of the IES to achieve a "Zero Waste" system. I am attempting to do this by creating a microbial fertilizer, in which the microbes that are grown in this water benefit any plant life that we are trying to sustain.

Figure 1: These pictures are just to display the Biodiesel Lab's algae system. The algae is grown in the wash water that was used in the biodiesel production process, and normally goes down the drain. This experiment was conducted with the water left over after the algae has been harvested for fish food.

Objectives

The main objective of this project was to test this leftover nutrient water for its viability as a microbial fertilizer, which could then be used in our Urban Agriculture program. This was done with materials typically found within IES, mainly nutrient wastewater and fish waste, which would contribute the base microbial community. I then tested different additives to the water and fish waste, to determine if any of them would improve the microbial community.

Methodology

In this project, I created our own nutrient water in order to do this experiment, as we do not currently produce enough algae in order to get the amount of water that was needed. The samples consisted of four treatments, including the control. The control was just the nutrient water and fish waste. Each subsequent trial was nutrient water, fish waste, and an additive. The additives that were tested were sucrose, fish hydrolysate, and humic acid. Each of these modifications were added to the water and fish waste in liquid form. Each trial had five replicates. Each sample was prepared with the proper mixture in an Erlenmeyer flask, and was then placed on a shaker table for three days at 120 rpm. During this time, small water samples were taken on a set time schedule, in order to measure bacterial growth. This was done by placing the water sample into a microcentrifuge tube and then drying it for multiple days. Over time, this would then give us the changes in weight of the dry mass of the water sample, which can roughly equate to bacterial growth.

After these samples had gone for three days, they were taken off the shaker table and placed in test tubes. I then filtered them and ran each of these samples through the ion chromatograph in order to determine the anion and cation concentration of each sample. The original nutrient water was also run through the ion chromatograph in order to determine the original ion concentrations.

Figure 2: This figure showcases the experimental setup, with each sample on the shaker table.

Figure 3: This figure is of the amount of microcentrifuge tubes that it took to measure all of the masses over the time of the experiment.

Results

The two main measurements taken during this experiment were dry microbial mass and cation and anion concentration of the samples. In terms of the changes in mass, the humic acid has the biggest difference, with the final mass being 2.562 µg heavier than the original. While we can attribute some of this to microbial growth, there were some flaws within the experiment. The fish waste was not able to be contained within the flask, so it was free floating throughout the water. This could have contaminated our sample masses. The samples that had the most fluctuation were the ones that were just fish waste and nutrient water, which varied, on average, from 0.6084 µg to 4.3608 µg in just 16 hours, before going back down to 1.9854 µg after another 16 hours.

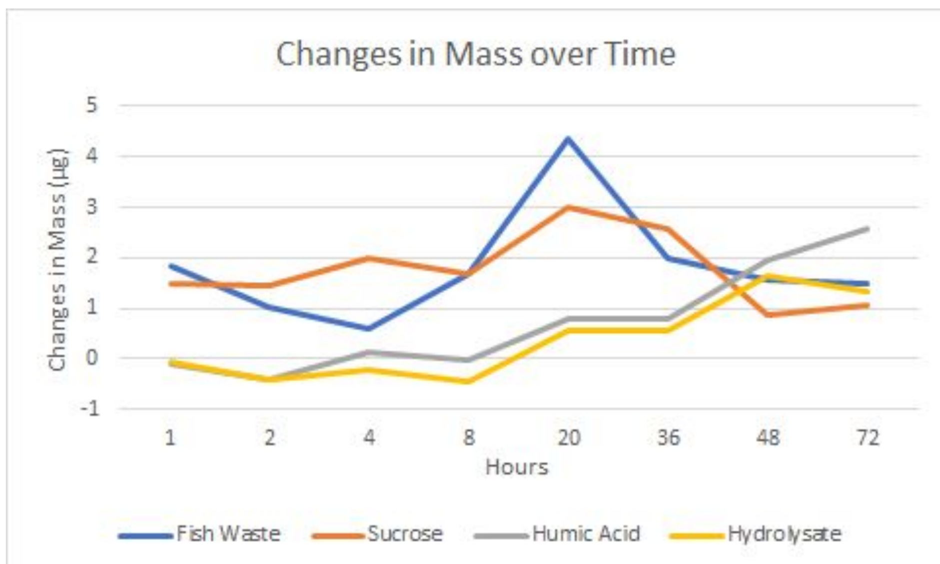

Figure 4: This graph shows the changes in sample mass over time for each sample.

Results

The ion concentrations yielded different results. The main ion values that we are interested in are the NPK values, which would be the ones most indicative of plant growth. This refers to the concentrations of nitrogen, phosphorus, and potassium in the water. For the anions, the samples with fish waste generally had the highest concentrations. The nitrate and nitrite values, on average, were significantly higher in the fish waste samples over the sucrose samples at the 0.05 level. Nitrogen levels in the fish waste were also generally higher than the humic acid and fish hydrolysate samples, but not significantly. The fish waste also yielded higher phosphate levels.

In terms of the cations, the fish hydrolysate samples yielded the highest ion concentrations. When compared to the control (just fish waste), fish hydrolysate had significantly higher concentrations for each of the cations besides NH_4. The humic acid samples also showed significantly higher concentrations of Mg, Na, and NH_4.

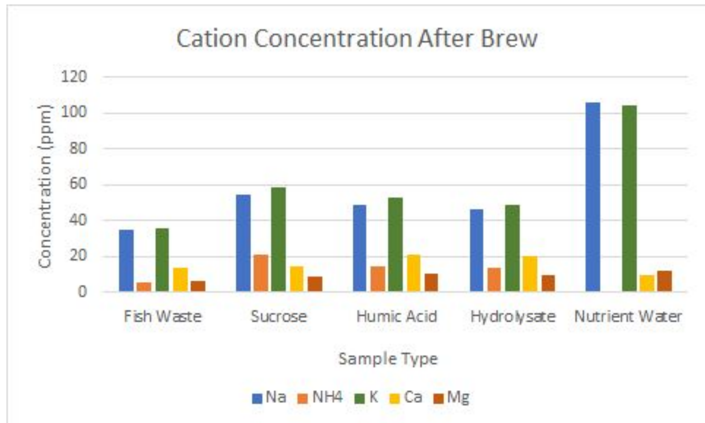

Figure 5: This graph shows the average cation concentration in each of the samples, as well as the original nutrient water.

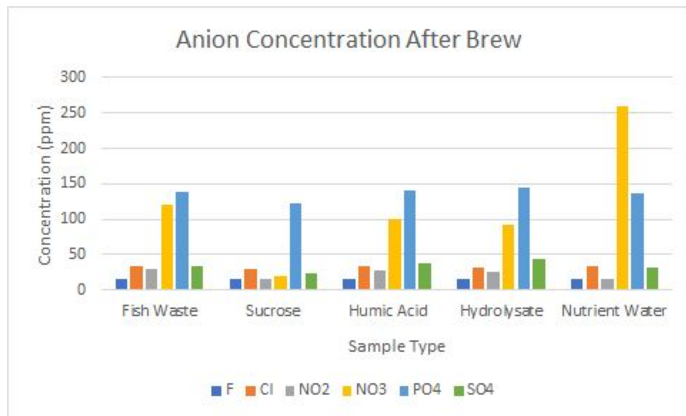

Figure 6: This graph shows the average cation concentration in each of the samples, as well as the original nutrient water.

Conclusion

In terms of the anion results, the fish waste would be the most prolific, as it had the most nitrogen and phosphorus at the end of the experiment. The fish hydrolysate plus fish waste would be the most fruitful in terms of the cations, as it consistently had higher concentrations. But, the trouble with this experiment is that higher ion concentrations does not equate to more significance. This is because a solution could yield high ion concentrations, but at the same time could cultivate a high bacterial culture. So, even though the humic acid solution could have a high NPK value, much of that could have been incorporated into the bacterial biomass, which would not show up in the ion chromatograph testing, due to the samples being filtered. We also know that the ion concentration is decreased by the bacterial cultivation as all of the samples showed decreased ions from the original nutrient water.

Looking forward, there is one major step that needs to be taken in order to determine the effectiveness of the fish waste brew as a fertilizer. We need to design a growth experiment in order to actually test how well bacterial growth corresponds to plant growth, which is what is currently being developed.